TWISTING MACHINE CAPABLE OF INDEPENDENTLY CONTROLLING TWISTING SPEED AND WINDING SPEED AND METHOD OF THE SAME

TECHNICAL FIELD

The present invention relates to a twisting machine capable of independently controlling the twisting speed of a thread or plurality of threads, i.e. the twisting density in a certain length and the winding speed of twisted thread.

The twisting of threads defined in a commercial context typically comprises either: covering a thread or a plurality of threads by rotating one or more threads around the thread; or alternatively, twisting a thread or a plurality of threads by twisting one or more threads around eachother.

Most textile articles including both knitted and woven fabrics, clothing etc. are inherently produced from twisted threads. One remarkable advantage of utilizing twisted threads in producing textile articles is surprisingly their strength, particularly their tensile strength, such that it is more difficult to break off the thread compared to a single untwisted thread in the same thickness. Likewise, a twisted thread is capable of extending in its longitudinal direction much more than an untwisted thread. In addition to these sound mechanical properties, twisted threads are often used by textile designers for creating cutting-edge fashion designs when for instance the threads to be twisted are selected from a group of various colors and formations. These advantageous properties lead the twisted threads to be widely utilized in producing textile products.

BACKGROUND OF THE INVENTION

Thread twisting technology generally comprises three known methods: the hollow spindle method, the two-for-one method; and the ring twisting method. Various twisting configurations can be obtained by employing these known methods. The

twisting configurations can be classified according to the twisting direction as either "S-twisting", or "Z-twisting" and according to the twisting technique as one or more of "covering", "fantasy twisting", and "false twisting".

In the hollow spindle method, a first bobbin which is rotated around its longitudinal axis by a motor and another bobbin which is stationary are provided. A first thread released from the stationary bobbin is introduced through an aperture extending along the axis of the rotated bobbin and another thread released from the rotated bobbin is simultaneously introduced through the aperture. The threads taken up from the separate bobbins are combined together in the aperture and twisting of the threads is accomplished by wrapping the thread released from the rotated bobbin around the thread released from the stationary bobbin so as to cover the thread released from the stationary bobbin.

In a subsequent step, the twisted thread is wound onto another bobbin for dispatching. Notwithstanding the fact that the number of stationary bobbins must be increased to introduce a plurality of threads into the aperture for covering thereof by the thread released from the rotated bobbin, the major disadvantage of the hollow spindle method is that the thread on the rotated bobbin must be prepared in advance for the resultant twisting configuration i.e. S-twisting, Z-twisting etc. Furthermore, the thread must be homogenously and tightly wound on the rotated bobbin prior to use which is a labor-intensive task. Another disadvantage of the hollow spindle method is that the entire bobbin is rotated, potentially causing excessive centrifugal forces depending on the rotation speed. This is why the hollow spindle method is preferred for covering but not for twisting threads together.

The two-for-one method equipment comprises a spindle having an aperture extending through its axis, a rotor rotating with the spindle, a bobbin having threads thereon and a casing surrounding the bobbin. The reason that this method is called "two-for-one" is that two turns are formed in the threads as the spindle performs one turn.

The two-for-one effect is achieved only if the casing and the bobbin are held stationary as the spindle rotates even though the casing is coaxially mounted with respect to the spindle. Holding the casing stationary is accomplished by providing a magnet couple between the casing and the body covering the casing. In other words, opposite poled magnets are fixed to the casing and to the body respectively.

In the two-for-one method, the threads are directed through the aperture of the spindle so that the threads perform one turn in the aperture of the spindle as the spindle performs one turn. In this manner, the threads are twisted and the first step of the two-for-one method is completed.

Once the twisted threads have passed through the aperture in the spindle, they are advanced over the rotor to a thread guide which is stationary as it is immovably secured to the machine body. Since the twisted threads are advanced to the thread guide, they perform one more turn between the rotor and the guide meaning that two turns are formed in the threads as the spindle performs one turn. In a subsequent step, the twisted threads are wound on a bobbin for dispatching.

Although both S-twisting and Z-twisting configurations can be achieved by the two-for-one method, the maximum number of threads provided on the bobbin is generally two. In practice employing more than two threads would not exploit the two-for-one method efficiently, since the threads are knotted or even broken off when released from the bobbin. Furthermore, even using two threads may cause knotting or even breaking off when the threads are slippery. Moreover, the threads to be twisted are wound on the bobbin before the two-for-one twisting begins which involves extra effort. Further, it is not possible to cover threads by the two-for-one method.

The ring twisting method equipment comprises a plurality of bobbins having untwisted threads provided thereon , speed-controlled rotating cylinders through

which the threads released from the bobbins are passed, a ring through which the threads are passed, a thread guide and a spool.

The threads provided from the bobbins are passed through the ring thus bunching the threads together. The bunch of threads is further advanced through the guide and wound onto the spool as it is rotating. The threads are therefore twisted before winding on the spool.

The immediate disadvantage of the ring twisting method is the failure to wind the twisted threads directly onto a bobbin, which will be dispatched to the end user. The ring twisting requires a further step to wind the twisted threads onto a bobbin independent from the spool. Moreover, the twisted thread is wound on the spool during use and the spool is rotated as the twisting is performed. As twisted threads accumulates on the spool, the centrifugal forces increase and so the spool must be changed regularly and the spool cannot be rotated at high speeds. Finally, as in two-for-one twisting, covering of threads is not possible by the ring twisting method.

The most frequently practiced twisting method over the years has been the two-for-one method and accordingly literature shows various studies for improving the two-for-one technology. For instance, US 3,406,511 discloses a spindle having a rotor rotatable with the spindle and a cylinder having a bobbin on which twisted threads are wound. In the cylinder, there is provided a rail element extending parallel to the axis of the cylinder. A thread guide mounted transversely to the rail element and being displaceable in the longitudinal direction of the rail element is provided for winding the twisted threads on the bobbin.

The bobbin in US 3,406,511, is engaged to a mandrel from its bottom end and said mandrel is associated with a head rotating eccentrically with respect to the axis of the spindle. The head is connected to a platform rotated by the spindle through a spring element. The cylinder is held stationary by an opposite poled magnet couple, one provided to the cylinder and one provided to the body.

As the spindle and the platform connected thereto are rotated, the bobbin rotates around the axis of the spindle. The thread guide is continuously moved in upper and lower directions and continuously provides twisted threads onto the bobbin so that the twisted threads are wound thereon. As the construction disclosed in US 3,406,511 comprises various eccentrically mounted masses i.e. machine parts including the bobbin, rail element, spring element and so on, the centrifugal forces induced by this eccentricity can not be balanced by the machine configuration. This failure is a major obstacle to the spindle speed and the winding speed of the twisting machine in the US 3,406,511 being set to higher values which leads to inefficiency in twisting of threads.

US 3,368,336 discloses a version of the machine of US 3,406,511 and includes substantially identical machine parts to the latter. The distinction in US 3,368,336 is that the thread guide can be driven in a vertical direction through magnetic force. Achievement of this movement is performed by an opposite poled magnet couple (one magnet movably provided on the outer surface of the body and one magnet provided on an engagement element engaging the thread guide to the rail). However, the same disadvantages apply to this version, i.e. the incapability of operating the machine at high speeds due to the extreme centrifugal forces induced.

US 3,834,146 discloses a twisting machine comprising a rotatable spindle having an aperture extending along the axis thereof in which a plurality of threads taken from a plurality of bobbins and incorporated together are provided. The spindle has an opening radially extending therefrom and the threads are taken out through the opening and advanced further via the outer surface of a rotor to a winding drum for winding onto a bobbin.

The rotation of the spindle and the rotor connected to it in US 3,834,146 is provided by a motor transmitting rotational movement through a belt pulley and a gear reduction mechanism. The rotational movement of the winding drum for winding the twisted threads onto the bobbin is achieved by another gear reduction mechanism. The winding speed of the twisted threads (i.e. the rotation speed of

the winding drum) is dependent upon the gear reduction mechanism or any other power transmitting means that would be replaced with the gear mechanism. The only way to change the rotation speed, independently from the spindle speed, of the winding drum is to change the dimensions of the gear reduction mechanism, which suggests an extremely inflexible arrangement.

EP 0 867 541 discloses a twisting method operated according to the two-for-one method on a machine having first and second centering points. The method comprises introducing twisted threads into a balloon formation zone from the second centering point and then winding the twisted threads onto a bobbin. The arrangement introduced in EP 0 867 541 is substantially identical to that of US 3,406,511 and US 3,368,336 and has the same disadvantages set forth above.

US 6,047,535 discloses an arrangement providing energy and signal transmission between a first stationary zone and a second zone. The energy transmission is provided by a transformer and the energy is transmitted to movable machine parts including a spindle. The signal generated and modulated by a control unit controls various functional outputs including thread winding breaking, spindle rotation etc.

JP 59-106527 discloses a twisting machine comprising a spindle, a rotor mounted on the spindle, a gear mounted to an end of the spindle, another gear mounted on a winding drum for matching the gear on the spindle, and a bobbin on which twisted threads from the winding drum are wound.

As in the above mentioned references, in JP 59-106527, the casing having the bobbin on which twisted threads are wound is kept stationary by a magnet couple. The winding drum speed is set through the gear couple, i.e. the gear on one end of the spindle and the matching gear on the winding drum, so that the winding speed and the rotor speed can be held at different respective values while the twisting machine is operated. However, among the most readily identifiable disadvantages of JP 59-106527, is the fact that the winding drum speed cannot be adjusted while the twisting machine is operating, as the dimensions of the gears on the spindle and on the winding drum cannot be changed simultaneously.

Since the winding drum speed can only be changed by the replacement of the gear couple with a gear couple of different dimensions, this would lead to an infinite number of gear couple configurations in theory. Furthermore, the arrangement in JP 59-106527 induces extreme centrifugal forces while the twisting machine is in operation, as the machine comprises various masses mounted eccentrically from the spindle rotation axis.

In the light of the disadvantages pointed out above, there is a need to provide a way of setting spindle speed and winding drum speed independently while a twisting machine is in operation.

DESCRIPTION OF INVENTION

It is an object of the present invention to enhance the efficiency of thread twisting by independently controlling and altering the speed of thread twisting (i.e. the number of twists per meter) and the winding speed of the twisted threads onto a bobbin as desired.

Another object of the present invention is to minimize the centrifugal forces and vibrations experienced in a twisting machine to extend the operation life cycle of twisting machines.

From a first aspect, the present invention provides a twisting machine comprising: a spindle to which a thread or a plurality of threads is/are introduced in use and from which the thread or the plurality of threads is/are taken out in use, the spindle being driven by a spindle driving motor ; a rotor being associated with the spindle and being in contact with the thread or plurality of threads taken out of the spindle while rotating in use; a winding drum for winding the thread or the plurality of threads, which advance from the rotor and are conveyed via a thread guide, onto a bobbin in use; and a stationary carrier carrying the bobbin, characterized in that the machine comprises means for independently moving the spindle and winding drum.

From a further aspect, the present invention provides a method for twisting threads; comprising introducing a thread or plurality of threads into a spindle having an aperture extending along the axis thereof, said spindle being driven by a motor; taking out the twisted thread or the plurality of threads from the spindle and advancing the threads from the outer surface of a rotor; and further advancing the twisted threads to a winding drum for winding the twisted threads onto a bobbin, characterized in that the method comprises the steps of;

- transmitting the movement of a secondary motor to a primary power transmission means rotatable independently from the spindle, said primary power transmission means being arranged coaxially with the spindle,
- transmitting the movement provided by the primary power transmission means to a secondary power transmission means capable of performing planetary movement with respect to the spindle axis,
- transmitting the movement provided by the secondary power transmission means to a tertiary power transmission means rotatable independently from the spindle and said tertiary power transmission means being arranged coaxially with the spindle .

The preferred method and machine of the present invention further comprises a step for holding the carrier carrying the bobbin onto which twisted threads are wound stationary without using magnets. In order to hold the carrier, a mechanism for performing a planetary movement with respect to the axis of the spindle and dissipating the power transmission in its own arrangement for preventing carrier rotation is provided.

DESCRIPTION OF FIGURES

Preferred embodiments of the invention will now be described, by way of example only, and with reference to the accompanying drawings in which::

Figure 1 is a perspective view of a twisting machine according to the invention;

Figure 2 is a perspective view of the motion transmission mechanism of the twisting machine of Figure 1;

Figure 3 is a cross-sectional view of the motion transmission mechanism of Figure 2;

Figure 4 is a perspective view of an alternative motion transmission mechanism of a twisting machine according to the invention.;

Figure 5 is a perspective view of another alternative motion transmission mechanism of a twisting machine according to the invention;

Figure 6 is a schematic representation of the mechanism for keeping the carrier of a twisting machine according to the invention stationary;

Figure 7 is a schematic representation of the mechanism for keeping the carrier stationary and the motion transmission mechanism of a twisting machine according to the invention;

Figure 8 is a schematic representation of an alternative mechanism for keeping the carrier of a twisting machine according to the invention stationary;

Figure 9 is a schematic representation of an alternative mechanism for keeping the carrier stationary and the motion transmission mechanism of a twisting machine according to the invention.;

Figure 10 is a schematic representation of an alternative mechanism for keeping the carrier of a twisting machine according to the invention stationary;

Figure 11 is a schematic representation of an alternative mechanism for keeping the carrier stationary and the motion transmission mechanism of a twisting machine according to the invention;

Figure 12 is a perspective view of the covering process being carried out by the twisting machine of Figure 1;

Figure 13 is a perspective view of the lubricant housing of a twisting machine according to the invention;

Figure 14 illustrates the driving mechanism of the winding drum and yarn feeder of a twisting machine according to the invention;

Figure 15 illustrates the motion transmission from the yarn feeder to the thread waxing mechanism of a twisting machine according to the invention;

Figure 16 illustrates the twisted thread winding termination mechanism for measuring when the bobbin has a predetermined thickness according to the invention;

Figure 17 illustrates an alternative twisted thread winding termination mechanism for measuring when the bobbin has a predetermined thickness according to the invention; and

Figure 18 illustrates an alternative twisted thread winding termination mechanism for measuring when the bobbin has a predetermined thickness according to the invention.

DETAILED DESCRIPTION OF THE INVENTION

In Figure 1, a general perspective view of a twisting machine according to the invention is illustrated.

In general terms, the twisting machine comprises a base portion including a hollow spindle 1 adapted to rotate about its axis and a substantially cylindrical rotor 12 positioned coaxially with the spindle at the upper end thereof and having a greater diameter than that of the spindle as will be described in further detail below. As shown in Figure 2, an aperture 100 is provided in the spindle 1 to extend perpendicular to the axis thereof at a level just below the rotor 12 to link the interior of the hollow spindle to the exterior thereof. A thread guide head 43 is provided a desired distance above the rotor 12 and coaxial with the spindle 1.

In the twisting machine according to the invention when being used in a twisting configuration, the thread or plurality of threads 70 to be twisted is/are fed into the machine through the lower end of the spindle 1. The threads pass along the spindle, out through the aperture 100 and over the radially outer surface of rotor 12. The twisted threads 44 are then directed to a thread guide head 43 secured above an upper table 56 and through which the threads 44 are introduced to extend downwardly. The threads extending from the edge of rotor 12 to thread guide head 43 rotate around the spindle 1 axis in use as the rotor 12 rotates and so form a balloon shape around the twisting machine. The height of the balloon can be modified by altering the height of the thread guide head 43 above the upper table 56.

The twisted threads 44 are then passed through a pig tail 42 and further advanced to a yarn feeder pulley 49 secured to the upper table 56. Afterwards the twisted threads are directed to a wax 50 for waxing thereof and then fed to a winding drum 46 for winding the twisted threads onto a bobbin 45. In the particular embodiment shown in Figure 1, 4 threads are being twisted together. It will be appreciated however that the machine could be used to twist a different number of threads of from 2 to 8 or more.

In Figure 2, the motion transmission mechanism is illustrated in perspective view and the same mechanism is illustrated in cross-sectional view in Figure 3. The spindle 1 is driven by a driving motor 27 for rotating thereof, and a rotor 12

connected coaxially to the spindle 1 is rotated with the same rotation speed of the spindle 1.

A planetary pulley mechanism 4 is coaxially provided) on the spindle 1, and this pulley 4 is rotated by a winding drum driving motor 28 independently from the spindle driving motor 27. The actuation provided by the winding drum driving motor 28 is preferably transmitted to the planetary pulley mechanism 4 by a winding drum driving belt 30. A ball bearing is provided between the planetary pulley mechanism 4 and the spindle 1 so that the outer ring of the ball bearing rotates with the planetary pulley mechanism 4 and the inner ring of the ball bearing rotates with the spindle 1.

The planetary pulley mechanism 4 is fixed to a lower collar 33 having a rotatable gear 10 (a lower rotatable gear) at one end thereof and the lower collar 33 being coaxially arranged on the spindle 1. Thus as the planetary pulley mechanism 4 is rotated, the gear 10 is rotated accordingly with the same rotational speed. The rotatable gear 10 transmits its rotational motion to a primary planetary gear 6, capable of performing planetary motion around the spindle 1 axis, by a lower rotatable gear belt 35. A primary power transmission spindle 21 is provided, preferably by tight engagement, in an opening extending along the axis of the primary planetary gear 6 so that the primary power transmission spindle 21 can transmit its motion along its axis. As the primary power transmission spindle 21 passes through the rotor 12 and a rotor lower piece 11, the primary power transmission spindle 21 is rotatably housed to a primary bearing housing 23 in which bearings are mounted. The primary power transmission spindle 21 has a secondary planetary gear 8 mounted at the other end being at the upper side of the rotor 12. As the secondary planetary gear 8 is preferably tightly engaged to the primary power transmission spindle 21, the secondary planetary gear 8, capable of performing planetary motion around the spindle 1 axis, rotates with the same rotational speed as the primary planetary gear 6.

Furthermore, since the primary power transmission spindle 21 is associated with the rotor 12, which is rotated by the spindle 1, the primary power transmission

spindle 21 has a certain linear velocity with respect to the spindle 1 axis. Consequently, both the primary and secondary planetary gears 6,8 rotate both about the power transmission spindle 21 axis and about the spindle 1 axis, so performing planetary motions.

The secondary planetary gear 8 transmits its rotational motion to a rotatable gear 17, an upper rotatable gear, mounted to one end of an upper collar 38 being coaxially arranged on the spindle 1 by an upper rotatable gear belt 36. A ball bearing is provided between the upper rotatable gear 17 and the spindle 1 so that the outer ring of the ball bearing rotates with the upper rotatable gear 17 and the inner ring of the ball bearing rotates with the spindle 1. The upper collar 38 has a yarn feeder pulley 14 and a winding drum driving pulley 15 at its other end, both being arranged coaxially with the spindle 1 axis. The pulleys 14,15 preferably rotate with the same rotation speed as the upper collar 38.

Consequently, on the same machine axis, i.e. on the spindle axis, the thread twisting speed and winding speed of the twisted thread are independently adjusted.

The speeds of the spindle driving motor 27 and the winding drum driving motor 28 can be adjusted as desired through a control unit or independently without employing a control unit.

In Figure 2 and Figure 3, the mechanism used to keep the carrier carrying the winding drum 46, and the bobbin 45 on which twisted threads are wound, stationary without employing magnetic means is also shown.

A lower stationary gear 9 is provided on the outer surface of the lower collar 33, so the lower stationary gear 9 is coaxially mounted to the spindle 1 axis with the collar 33. The lower stationary gear 9 is fixed to a fixing platform 26 by attaching means 25 and the fixing platform 26 is immovably connected to a sheet metal plate 24 attached to the body of the twisting machine. A ball bearing is provided between the lower stationary gear 9 and the lower collar 33 and while the inner

ring of the ball bearing is rotatable with the lower collar 33, the outer ring is kept stationary.

A lower stationary gear belt 34 is mounted between the lower stationary gear 9 and a tertiary planetary gear 5 for performing planetary motion around the spindle 1 axis. A first end of secondary planetary spindle 20 is provided in an opening extending along the axis of the tertiary planetary gear 5. The secondary planetary spindle 20 has a quaternary planetary gear 7 provided at the other end thereof in a substantially identical manner to the mechanism described above for Figures 2 and 3. The secondary planetary spindle performs planetary rotation around the spindle 1 axis. Since the secondary planetary spindle 20 passes through the rotor 12, which is rotated by the spindle 1, the secondary planetary spindle 20 has a certain linear velocity with respect to the spindle 1 axis. Consequently, both the tertiary and quaternary planetary gears 5,7 rotate both about the secondary planetary spindle 20 axis and about the spindle 1 axis, so performing planetary motions around the spindle 1 axis. An upper stationary gear belt 37 is mounted between the quaternary planetary gear 7 and an upper stationary gear 16 mounted on the outer surface of the upper collar 38. A ball bearing is provided between the upper stationary gear 16 and the upper collar 38, and while the inner ring of the ball bearing is rotatable with the upper collar 38, the outer ring is kept stationary. The upper stationary gear 16 keeps its stationary position, i.e. does not rotate, for the reasons to be explained with reference to Figures 6 to 11. Since the carrier 13 carrying the winding drum 46 and the bobbin 45 is fixed to the upper stationary gear 16, the carrier also keeps its stationary position, i.e. it does not rotate around the spindle 1 axis.

The embodiment described above is a preferred construction of the device of the invention and preferably, the number of teeth and/or the diameters of the lower stationery gear 9 and the upper stationary gear 16 are identical.

However, if the number of teeth and/or the diameters of the lower stationery gear 9 and the upper stationary gear 16 are different from each other then the carrier might have a slight turning motion depending on the difference in the number of

teeth and/or the respective diameters. This situation would apply when the belts 34,37 used are the trigger or toothed kind as in the best mode of the invention, the belts having more or less teeth to match with the gears 9,5,7,16.

In the preferred embodiment of the present invention, the elements 6,8;5,7 performing planetary motion around the spindle 1 and the elements 10,17;9,16 associated with those 6,8;5,7 performing planetary motion are preferably gears and the motion transmission belts 34,35,36,37 between these gears 6,8;5,7,10,17;9,16 are trigger belts.

An alternative mechanism providing independent adjustment of the twisting speed and the thread winding speed without employing belts is illustrated in Figure 4. According to the figure, the gears 6,8 performing planetary motion around the spindle 1 directly match the rotatable gears 10,17 coaxially mounted on the spindle 1 axis.

In this alternative, similarly, the gears 5,7 performing planetary motion around the spindle 1 axis for preventing rotation of the carrier without employing magnets, directly match the gears 9,16 coaxially mounted on the spindle axis 1.

In Figure 5, an alternative mechanism comprising a bevel gear group providing independent adjustment of the twisting speed and the thread winding speed is illustrated. In this alternative, the lower rotatable gear 10 and the upper rotatable gear 17 are replaced with bevel gears. Furthermore, motion transmission between the lower rotatable gear 10 and the upper rotatable gear 17 is provided by primary and secondary bevel gears 6,8 matching the lower rotatable gear 10 and the upper rotatable gear 17 and mounted substantially radially – perpendicularly - to the spindle 1 axis. The primary and secondary bevel gears 6,8 perform planetary motion around the spindle 1 axis. In this alternative, the number of gears performing planetary motion is at least one, and selected as two preferably.

The alternative embodiment shown in Figure 5 comprises a magnet couple 68, one of which is provided on the body of the twisting machine and has an opposite

pole with respect to the other which is provided on the carrier 13 for keeping the carrier 13 stationary, while the spindle speed and the twisted thread winding speed are adjusted independently.

As another alternative for adjusting the thread twisting speed and twisted thread winding speed independently, the motion transmission between the lower rotatable gear 10 and primary planetary gear 6; and similarly the motion transmission between the secondary planetary gear 8 and the upper rotatable gear 17 can be provided, without a mechanical connection, by magnetic gear couples or magnetic cylindrical means. The same motion transmission can be employed for keeping the carrier 13 stationary. In this case, the lower stationary gear 9 and tertiary planetary gear 5; and similarly the quaternary planetary gear 7 and upper stationary gear become magnetic gear couples or magnetic cylindrical means.

Alternatively, the lower rotatable gear 10, the primary planetary gear 6, the secondary planetary gear 8 and the upper rotatable gear 17 could be selected as pulley gears or chain gears. In this latter case, the motion transfer between the chain gears is provided by chains. Furthermore, all of the above-mentioned alternatives set forth e.g. magnetic gear couples, chain gears etc. for independently adjusting the twisting speed, i.e. the spindle speed, and the thread winding speed, i.e. winding drum speed, apply also to the motion transmission mechanism provided to keep the carrier 13 stationary.

Figure 6 schematically illustrates the mechanism for keeping the carrier of the twisting machine of Figures 1 to 3 stationary. This figure is intended to describe the way in which the upper stationary gear 16 and the carrier 13 connected thereto are prevented from rotating without an attachment to the body of the twisting machine.

The relative velocities of the component parts are defined as follows, where:

w_0 = spindle angular velocity

w_1 = lower stationary gear angular velocity

w_2 = angular velocity of the tertiary planetary gear around the secondary planetary spindle axis

m = number of teeth of the lower stationary gear
n = number of teeth of the tertiary planetary gear
l = number of teeth of the quaternary planetary gear
k = number of teeth of the upper stationary gear

$w_2 = (w_0 + w_1) * m/n$

and from the similarity;

$w_2 = (w_0 + w_3) * k/l$

In this case;

$(w_0 + w_1) * m/n = (w_0 + w_3) * k/l$

So, if $m/n = k/l$ then $w_1 = w_3$.

As seen from the Figure 3, since the lower stationary gear 9 is fixed to the body, $w_1 = 0$, so the angular velocity of the upper stationary gear becomes $w_3 = 0$.

Figure 7 schematically illustrates the mechanism for keeping the carrier of Figure 6 stationary and the motion transmission mechanism of the twisting machine according to the invention.

Figure 8 schematically illustrates an alternative mechanism for keeping the carrier of the twisting machine according to the invention stationary. The theory discussed above for Figure 6 also applies to this mechanism. As shown, in this alternative mechanism each of the lower stationary gear 9, the tertiary planetary gear 5, the quaternary planetary gear 7 and the upper stationary gear 16 comprise toothed gear wheels which interengage in respective pairs such that no belts need to be used. The remaining parts of Figure 8 correspond to those of Figure 6. Figure 9 shows the mechanism of Figure 8 for keeping the carrier stationary combined with an equivalent motion transmission mechanism.

Figure 10 schematically illustrates an alternative mechanism for keeping the carrier of the twisting machine according to the invention stationary. In this embodiment, the lower stationary gear 9 and the upper stationary gear 16 comprise ring gears having teeth on the inner surface thereof which engage with the tertiary and quaternary planetary gears respectively (those gears comprising toothed gear wheels). Again, the remaining parts of this Figure correspond to those of Figure 6. Again, the theory mentioned for Figure 6 applies to this mechanism.

Figure 11 shows the mechanism of Figure 10 for keeping the carrier stationary combined with an equivalent motion transmission mechanism.

Figure 12 is a perspective view of a twisting machine according to the invention being used in a covering process. In use, a thread or plurality of threads 70 are passed through the thread guide head 43 from above, are covered by a thread 71 which is passed through an opening at the lower end of the spindle 1, out of the spindle, over the rotor 12 and upwardly to enter the thread guide head 43 with the other threads 70. Through this process, covering twisting is performed . In the particular embodiment shown, 5 threads are being covered using a single thread. It will be appreciated however that one or more threads could be covered by either a single thread, a plurality of threads twisted together or a plurality of threads extending parallel to one another.

Figure 13 illustrates the lubricant housing having ball bearings of a twisting machine according to the invention. When the spindle 1 is rotated at high speeds, centrifugal forces arise, causing the lubricant to move to the outer most walls in the bearing housings 22,23 in which the ball bearings of the primary and secondary planetary spindles 20,21 are mounted. In order to prevent the lubricant leakage from the bearing housings 22,23, lids 54 are mounted to the bearing housings 22,23.

Figure 14 illustrates the driving mechanism of the winding drum and yarn feeder of a twisting machine according to the invention. The winding drum driving pulley 15

transmits its motion received from the upper collar 38 to a winding drum pulley 51 coupled with the winding drum 46 by a winding drum driving belt 40. Similarly, yarn feeder pulley 14 transmits its motion to a yarn feeder spindle 41 by a yarn feeder belt 39. The yarn feeder belt 39 transmits its motion to a yarn feeder spindle pulley 48 mounted on the yarn feeder spindle 41. A yarn feeder roller 49 is provided on the yarn feeder spindle 41 and the twisted threads are passed around the yarn feeder roller 49 for drawing the twisted threads by the winding drum 46 for winding thereof on the bobbin 45.

The winding drum 46 is secured to the carrier 13 by fixation means and the winding drum 46, rotated by the actuation provided by the winding drum driving pulley 15, winds the twisted thread onto the bobbin. Rotation direction of the winding drum driving pulley 15 is altered by a middle pulley 52 on which the winding drum driving belt 40 is connected.

Figure 15 illustrates the motion transmission from the yarn feeder to the thread waxing mechanism of a twisting machine according to the invention when used for twisting. The twisted thread passing through the thread guide head 43 is further passed through the pig tail 42 and advanced to the wax 50 for waxing thereof. The wax 50 can be rotated around its own axis without driving by another means as seen in Figure 1. Alternatively, the wax 50 can be associated with the yarn feeder spindle 41 by a driving belt 57 for driving the wax 50. The twisted and waxed thread is directed to the winding drum 46 through an opening 47 in the upper table 56 without utilizing another directing means. So, channels 53 grooved on the winding drum 46 can directly wind the twisted thread conveyed from the upper table 56 onto the bobbin 45.

Figures 16 to 18 illustrate the mechanisms for terminating winding of the twisted thread when the bobbin has a predetermined thickness.

In Figure 16, a sensor operated according to a radio frequency sensing method is illustrated. As the twisted threads are wound onto the bobbin 45 the thickness thereof increases, a bobbin arm 58 securing the bobbin 45 to the carrier 13 slightly

rotates and a switch 59 mounted close to a tip of the bobbin arm 58 is forced to move so that the radio frequency generator 61 is actuated. The radio frequency 60 generated is received by a receiver 62 and once the radio frequency 60 rises to a predetermined level then the receiver 62 controls the motors to terminate the thread winding operation.

In Figure 17, a signal supplier 63 and a signal receiver 64 mutually positioned opposite each other are illustrated. The signal 65 permanently supplied by the signal supplier 63 to the signal receiver 64 is interrupted when the thickness of the bobbin increases to a certain level by the twisted threads and then the signal receiver 64 generates a signal for controlling the motors to terminate the thread winding operation.

In Figure 18, a sensor mechanism having a beam supplier-receiver and a reflector is illustrated. The reflector 66 is mounted at a tip of the bobbin arm 58. As the thickness of the bobbin increases by the wound twisted threads, the bobbin arm 58 in contact with the increased thickness of the bobbin slightly rotates and the beam 67 supplied by the beam supplier-receiver 68 alters its reflected direction so that it corresponds to the receiver section of the beam supplier-receiver 68. The receiver then generates a signal to control the motors to terminate the thread winding operation.